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Botanical Department (Extension Work)

DISEASES OF GINSENG



By JAMES M VAN HOOK

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CORNELL UNIVERSITY, ITHACA, N. Y.

May 31, 1904.

HON. CHARLES A. WIETING,

Commissioner of Agriculture, Albany.

Sir :—It is strange to the layman that as soon as a plant begins to be cultivated, it is subject to serious diseases and insect attacks. The reasons for these troubles under cultivation are several : the plant is taken into new and perhaps unnatural conditions ; it is exposed to fungi and insects that may not exist in its native places ; diseases are brought in by the interchange of plants from place to place or country to country. Many times, however, the wild plant is subject to diseases, but we have not observed them.

Ginseng has recently come into great prominence in this State. We are just beginning to learn how to grow it well. At the outset, diseases appear. We have been appealed to for help. The present bulletin is the result. It is a preliminary study. We shall be glad if ginseng growers report any diseases or difficulties of their crops.

New York State is one of the leading states in the growing of ginseng. Considering the value of the New York product and the attention given to the plant, it is not improbable that New York leads the states. The interest in the plant is growing rapidly. Statistics have not yet been collected.

The profits in ginseng come from three sources : selling of seed, of roots one and two years old for planting, of dry roots for export. The price per pound for dried roots has averaged as follows for the United States :

1897	1898	1899	1900	1901
\$4.65	\$3 67	\$4.00	\$5.18	\$5.38

The northern and eastern ginseng seems to be preferred by the Chinese. The greater part of the American ginseng goes to the Hong Kong market. From 1858 to 1896, the United States exported annually an average of 361,526 pounds of dried root. The quantity is diminishing, as the wild supply is decreasing. In 1901, it is reported that the export was 149,069 pounds, with a value of \$801,672. In 1902, the crop was 154,063 pounds, valued at \$856,515. In 1903, it was 151,985 pounds, valued at \$796,008.

The present bulletin records the results of an investigation made in the New York ginseng gardens, under the supervision of Professor G. F. Atkinson.

Respectfully submitted,

L. H. BAILEY,

Director.

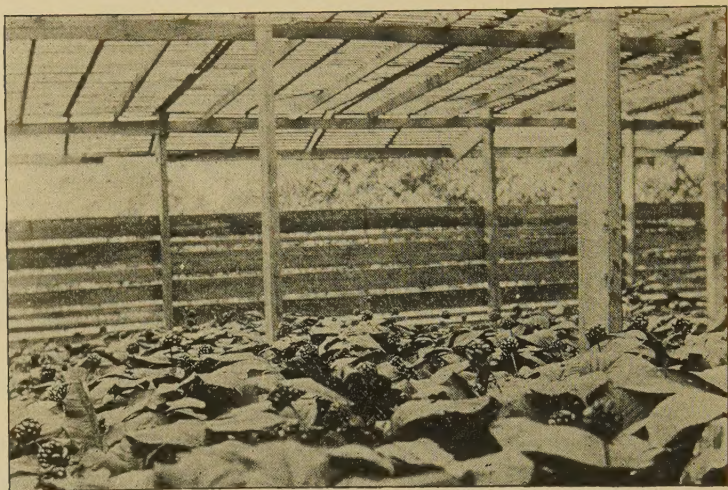


FIG. 18.—*A good crop of seed.*

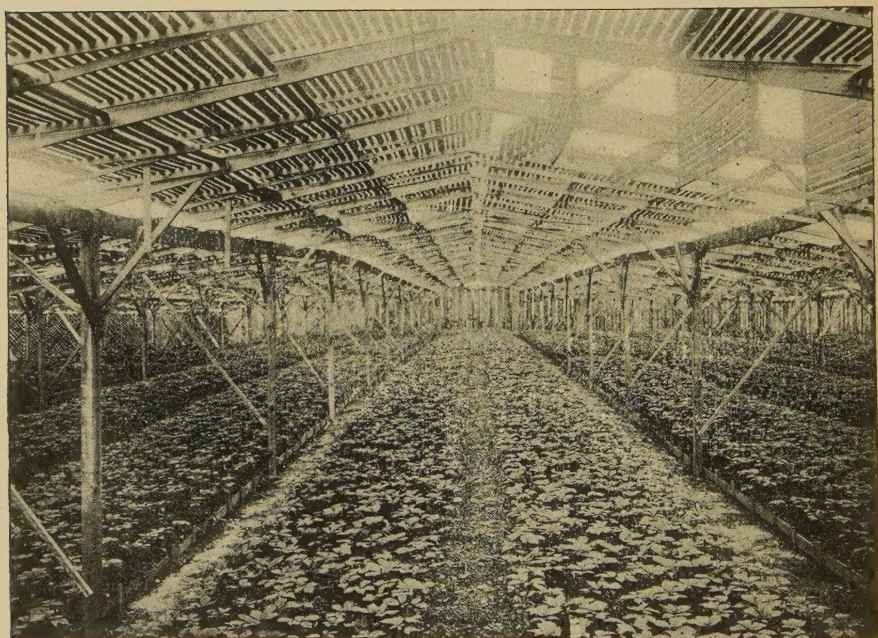


FIG. 19.—*The double bed, with top to conform. The entire top is in sections and can be quickly opened.*

SOME DISEASES OF GINSENG.

By J. M. VANHOOK.

One of the inducements often put forward for beginning the culture of ginseng, is that the plant is practically free from enemies.¹ While the plant in its wild state seems to be free of disease, the results of last season's study at once dispel the illusion as to the cultivated plant. The success of growing ginseng in this country seems remarkable, when we consider how recent the business is and how little we knew about the culture of the plant. The transplanting of the roots from the forest to surroundings apparently entirely different, seemed at first impossible; yet



FIG. 20.—*Advanced stages of the wilt as it appears in the bed.
Some of the plants not affected.*

this has been done very successfully—not that the environment really has been so much changed, but artificial means now supply the conditions under which the forest plant thrived. For example, artificial shade has been substituted for the natural shade of the forest. Not only has this shading been suc-

¹ In Saccardo's host index, we find but a single fungus mentioned as growing on our species of ginseng, either as a parasite or saprophyte. This fungus is *Diplodia panacis* (Fr.) Cke. I have never found any fungus on the plant in the forest, but have found an occasional rotted root, much like the root-rot so common during the past season. It is probable that a careful study of the wild plant would discover it to be subject to various diseases.

cessfully employed, but it seems to be a decided improvement, inasmuch as the amount of light can be regulated to suit the various changes in the weather.

The diseases which have been observed during the past season fall under two heads: those due to parasites; and those due to the conditions in which the plant exists under cultivation.

I. THE WILT OF OLD GINSENG PLANTS.

On June 5, 1903, a number of diseased ginseng plants were brought to the laboratory. The owner described the trouble as merely a wilting of the

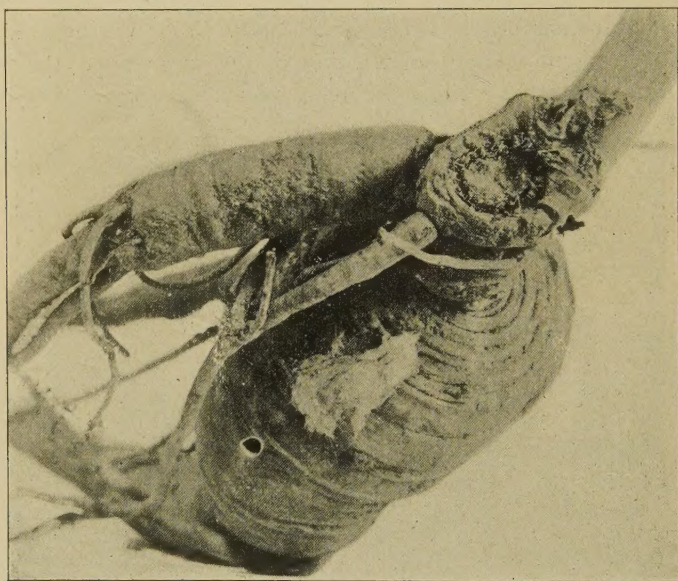


FIG. 21.—*Last year's scar, where the wilt fungus entered. (Natural size.)*

plants. These plants showed the wilt in various degrees of advancement, such as we see in Figs. 22-24. Professor Atkinson, to whose attention these wilted plants were first called, made an examination of their exterior and saw no indication of mechanical injury, or of attacks by any parasite. So he supposed the wilting due to a stoppage of the water supply, as is known to be the case with a number of other plants. Sections of the root and rootstock or perennial stem revealed a very decided yellowing of the vascular bundle (Figs. 25-27); whereas in the normal plant, although this ring may be observed in cross section, it is entirely white.

The subject was then placed in my hands for investigation. Sections of the root were made in the region of the discolored areas for examination with the aid of a microscope. The walls of the vessels of the affected bundles were quite yellow. Fig. 25 shows the perennial stem and root in section. The

streaks are prominent and, in the root, are situated just inside the bark or cortex. In the perennial stem, they are much broadened and irregular owing to the character of the bundles in this part of the plant.

The vascular bundles are a system of vessels that traverse the entire plant,—root, stem and leaf. They occur in groups or bundles, as is shown in Fig. 29. Here is a group of nine such vessels in cross-section. Their walls are much thicker than those of the ordinary cells that surround them. The purpose of the vessels in this region is to conduct the soil water (which contains food substance in solution) through the plant. This water evaporates in great quantities from the leaves, leaving the food substance behind. As long as the



FIG. 22.—*Second stage of the wilt.*

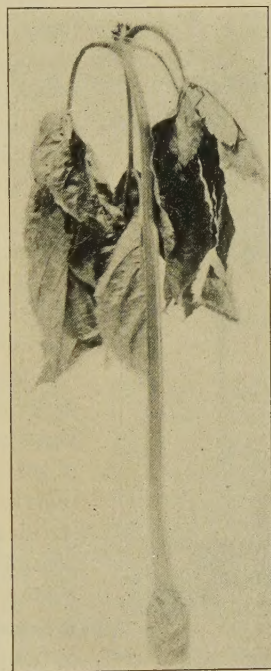


FIG. 23.—*Third stage of the wilt.*

supply of water is not checked, the plant remains turgid; when water is not available or when its upward passage is interfered with, the plant loses its turgor and wilting results.

In the present case, the vessels become clogged by the vegetative threads of a fungus (Fig. 29). In many places the vessel is completely filled with this growth. The threads pass readily through the walls of the vessels, but never, so far as can be ascertained, do they pass into the other cells of the root. The wilting may not be entirely due to the complete stoppage of the vessel, but the presence of the fungus certainly interferes with the physiological activity so

that the functions are not properly carried on. The yellowing indicates, perhaps, the beginning of the disintegration of the vessels.

The roots in the garden¹ where this wilt disease occurred, were purchased the autumn before and were healthy as far as could be ascertained. They sprouted and grew vigorously until about June first, when the wilting was first noticed. The trouble was confined principally to three beds. In two of these, containing about 1000 plants, 76 were affected, and a few had already been removed. Some others wilted later in the season.

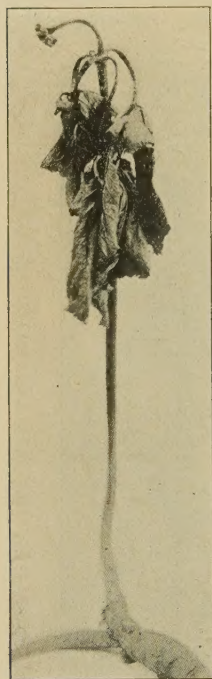


FIG. 24.—*Fourth stage of the wilt.*

When plants are affected with the wilt they droop very characteristically. The leaflets appear to lose their turgor at first in the thinner parts. Their tips lower, then the leaf-stalks and finally all of the leaves come to occupy the position seen in Figs. 22–24. Here they hang parallel to the stalk which remains in an upright position, though sometimes bent slightly near the top. It presents this appearance until completely dry. Fig. 20 shows three plants in an advanced stage of wilt, as they appear in the bed.

The fungus that causes this wilt disease probably enters the roots at the leaf-scars. Where the leaves break away from the root in the fall, open vessels are exposed, and the soil fungus enters.

Remedy.—From the fact that this trouble is confined in the main to the older roots which are naturally less vigorous, and from the nature of the fungus present, it seems advisable to dry all affected roots, and to remove the soil from the affected beds. If steam sterilization of beds or of the soil put into them were possible, this would be better on account of also ridding the gardens of other pests, such as snails or wireworms. The cure for numerous wilt diseases due to fungi acting in a similar manner has been found in the substitution of resistant varieties; and while this is not possible as yet in the case of American ginseng, a somewhat similar success can undoubtedly be attained by cultivating the more resistant roots, *i. e.*, the more vigorous ones. So long as old roots are kept for the purpose of producing seed, much root trouble may be expected. As roots become older they are

¹ The garden from which these diseased plants were obtained is in a village and is almost surrounded by buildings. A stable had formerly been located on a part of the inclosure. The soil is of gravel and clay. In making up the beds, well-rotted horse manure was mixed with the soil at the rate of about twenty loads to the acre. Bone meal was then spread on at the rate of eight quarts to a bed (42 x 4 ft). Then followed about a bushel of hardwood ashes; next, fine well-rotted horse manure, and finally coarse manure and sawdust. A mulch of about 2½ inches was thus formed.

more susceptible to disease; but at present it well pays to risk these old plants for another season for they may produce annually a hundred or more seeds each. The value of the seed crop each year would far exceed the value of the roots. When the stocking of new gardens becomes a secondary matter, roots will be sold as soon as they have reached the best condition for the dry market.

A MORE TECHNICAL ACCOUNT OF THE WILT DISEASE.

Cultures of the fungus.—Cultures of the fungus from the roots were made in the following manner: the roots were washed thoroughly, rinsed in distilled water, then in a one-tenth per cent. solution of mercuric chloride. With a flamed scalpel, the root, while still moist, was cut into for a short distance and split apart exposing the discolored vascular bundles. From this place with a sterilized, sharp-pointed dissecting knife, small pieces were cut from the discolored bundles. These little pieces of tissue were transferred to tubes containing potato

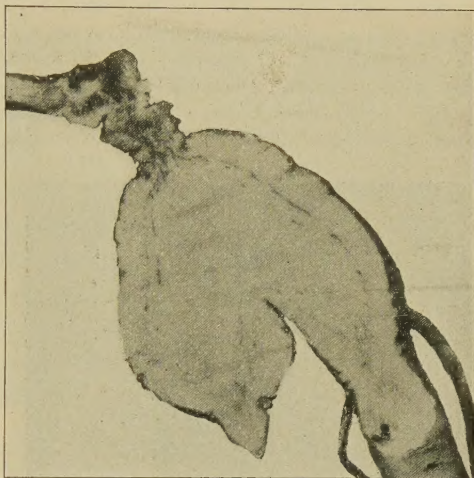


FIG. 25.—Root and perennial stem sectioned to show discolored areas in the vascular region due to the wilt fungus. (Natural size.)

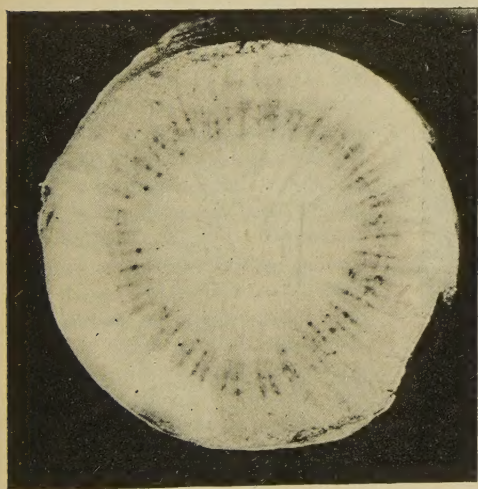


FIG. 26.—Section of root affected with wilt, showing the discolored regions. Enlarged $2\frac{1}{2}$ times.

and ginseng agar-media (prepared by stiffening a decoction of potatoes or ginseng, by the addition of agar-agar gelatine) containing food, upon which the fungus might grow. In like manner affected pieces of tissue were placed upon sterilized roots of ginseng. A great number of these cultures were made, and so carefully was the work of transplanting done, that only in two or three cases were even bacteria obtained, and this in unacidified tubes. The remainder of the tubes contained a pure growth of a fungus which was the same in every instance.

In Petrie dish cultures, there appear in about fifteen days, colonies about 2 cm. in diameter. They appear at first as a minute circular mass of hyaline threads which are about $2\mu^*$ in diameter; but as the colonies spread,

* A μ (micron) = about $\frac{1}{25400}$ in.

the central part becomes black from numerous knots developing on the threads (Fig. 30). These black knots are formed on the vegetative threads. Short cells are first cut off by the formation of walls across the thread. These cells broaden and multiply until knots of about 100 to 300 μ in length are formed. They are hyaline at first, but immediately become darker in color until in mass they look black. To the naked eye they appear as a granular mass; with an ordinary hand lens, however, they are quite distinct.

The surface of the colonies is covered with a loose web of fungus threads which bear the spores or conidia. These are the fruiting threads (conidiophores) of the fungus. These fruiting threads are normally erect, but when long they are prostrate. The prostrate ones send up secondary stalks which bear short branches. These secondary stalks are in form



FIG. 27.—Root with bark removed. The streaks are yellow and are due to the colored vascular bundles. (Natural size.)

like the normal erect ones and both are variously branched, but for the most part the branches grow in whorls. The ordinary upright fruiting stalks are from 200 to 275 μ long (sometimes 500 μ) and from 2½ to 3 μ thick. Fig. 31 shows a number of these in various stages and of various forms,—Fig. 31 (a) being typical. Here we see the general tendency to bear a whorl of as many as five somewhat spindle-shaped branches, 10 to 25 μ long. These are a little curved and taper toward the end. Branching in whorls is the usual form, and sometimes this is exceedingly regular. The prostrate forms seem to appear at a later period of growth. The terminal branch is longer than the others (50 to 60 μ). Each branch bears at the end a head or mass of spores surrounded by a coat of mucus. These globular heads appeared at first to be a single spore, especially since they are very small and difficult to observe. They are only 6 to 10 μ in diameter. Their shining appearance, however, suggested that they were either surrounded by a coat of slime or a film of water as is sometimes the case in culture dishes where the moisture is abundant. I dried some of these masses but they only shrunk slightly and became somewhat irregular in outline. If they had been held

together by moisture, drying would have caused them to fall apart. By examining with a microscope some of the colonies in a freshly opened dish, I afterward found a number where sufficient moisture had been present to dissolve the slime from some of the heads. The fruiting stalks then appeared as in Fig. 31 (b). I frequently observed these globular heads 14 μ in diameter, and at such times they presented a granular appearance which is really due to the spores within. This is at maturity when the spores are larger and the slime perhaps thinner or partly dissolved. (The best method of studying these is to remove

a small colony to a slide and examine without a cover, for the heads dissolve instantly on the application of liquids.) The spores are very minute and vary a great deal in size. They are oblong or elliptical and 2 to 5 by 1 to 2 μ .

How the fungus enters.—When the stem separates from the rootstock at the end of the season it leaves a scar (Fig. 21). At this place the vascular bundles are left open. Fig. 28

shows such a scar in longitudinal section and the vascular bundles (v). The scar is finally partially protected by a layer of cork cells (c). The bundles, however, do not receive this protection for a number of years, if ever. A section through last year's scar (where the stem had been separated for almost a year) showed a cortical layer 15 to 50 μ in thickness; but the bundles were still unhealed and the fungus threads could enter. The scars do sometimes heal entirely by a growing together of the cambium,

but often this is not completed for fifteen or twenty years. Sections of the perennial stem of affected plants show the fungus everywhere present in the vessels. Within the vessels and near the point of entrance of the fungus, where the vessels have begun to disintegrate, knots of fungus threads similar to those in Fig. 30 may be seen. It seems quite conclusive that the fungus enters the root through these open vessels.

What the fungus is.—As to the identity of this fungus the conidial form without doubt belongs to the genus *Acrostalagmus*. While differing somewhat from the descriptions of *A. albus* Pr., I do not consider these differences as sufficient to form a distinct species. The cultures at present indicate the development of a perfect stage. The surface of eight month old cultures is covered with what is undoubtedly young perithecia.

The wilting and dying of plants through a stoppage of their water supply in the above described, is not of rare occurrence. Following are some references to the literature :

Asters, Smith, R. A., Mass. Sta. Bull. 79, 1902.

Carnations, Britton, W. E., Amer. Florist, 14, No. 545, p. 431, 1898.

Gardening, 7, No. 153, p. 138, 1899.

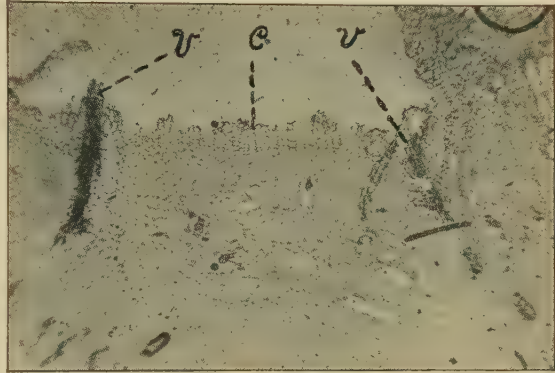


FIG. 28.—Longitudinal section through a leaf scar. v, the vascular bundles through which the fungus entered. c, cortical layer of cells forming over the scar. (Magnified 33 times.)

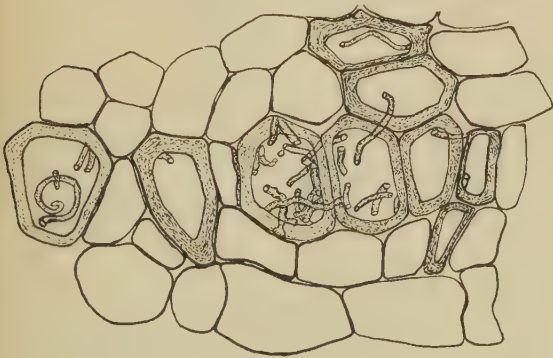


FIG. 29.—Cross-section of a vascular bundle. Fungus threads may be seen in the thick walled cells or vessels. (Magnified about 275 times.)

- Chrysanthemums, Mass. Sta. Rep., 1902, p. 57.
 Cotton, Atkinson, G. F., Ala. Sta. Bull. 41, 1892.
 Cotton, Watermelons, Cowpeas, Smith, E. F., Wilt Disease of Cotton, Watermelon and Cowpea. U. S. D. A. Div. Veg. Phys. and Path. Bull. 17, 1899.
 Cotton, Orton, W. A., Wilt Disease of Cotton and Its Control. U. S. D. A. Div. Veg. Phys. and Path. Bull. 27, 1900.
 Cowpea, Orton, W. A., The Wilt Disease of the Cowpea and Its Control. U. S. D. A. Bur. Plant Industry, Bull. 17, 1902.
 Tomatoes, Massee, G., Gard. Chron., 17, p. 107, 1895.



FIG. 30.—Black knots formed on the vegetative threads of the wilt fungus. (Magnified about 200 times.)

I. WILT OF SEEDLINGS.

Seedlings wilt from several causes. Their appearance above ground when affected with one of various troubles below the surface is strikingly similar. "End rot" of seedlings, damping off and insect injuries may each bring about wilt.

1 *Damping off by Rhizoctonia**.—When affected with this "damping



FIG. 31.—Spore-bearing stalks of the wilt fungus *Acrostalagmus albus* Pr. The spores are borne in heads and are held together at first by a coat of slime. (a, b, c enlarged 335 times, d, e, f 285 times.)

**Rhizoctonia* is termed a sterile fungus since it does not produce spores in the ordinary manner. It may be distinguished, however, by the vegetative part if placed under a microscope. The branches of the threads are divided by cross-walls near the point of union with the thread (Fig. 16). At this point also, the branches are usually slightly constricted, especially in the younger threads. These are frequently hyaline and vacuolate.

For more than a decade, *Rhizoctonia* has been known in this country to be the cause of plant disease. Experiments have proved it to be often purely parasitic. Among the diseases produced by it is that of "damping off," where it destroys seedlings. Some of the plants it is known to attack are ornamental asparagus, china aster, bean, beet, carnation, carrot, celery, cotton, lettuce, potato, radish, rhubarb, sweet-william and violet. Bulletin 186 of this station is devoted entirely to a study of the structure, life history, occurrence, parasitism and means of prevention of *Rhizoctonia*.

off" fungus the plants often fall over, making a bend at the surface of the soil, as shown in Fig. 32. When attacked below the surface the plant wilts. Specimens of this fungus were brought from a ginseng garden by Professor

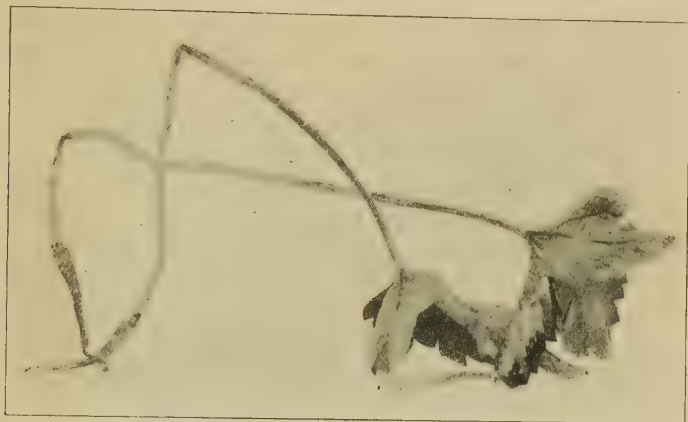


FIG. 32.—The effect of "damping off" on ginseng seedlings.
(Natural size.)

Atkinson in June. These were taken up with a quantity of the soil, so as to preserve them in as natural conditions as possible. Fungus threads in and around the affected parts of the stem, when placed under a microscope, present the appearance shown in Fig.

33. These are the threads of the sterile fungus *rhizoctonia*, now known to be mischievous in many kinds of plants. Since this fungus has been found to be most destructive to plants when they are surrounded by unfavorable conditions (*i. e.*, when the soil is too moist and not well aired), the best means of preventing the trouble is to be secured in regulating these conditions. The air should circulate freely among the plants, and the soil must not be wet and packed about these tender young stems. Stirring the surface of the beds to the depth of an inch will dry out the top soil and at the same time preserve the moisture below.

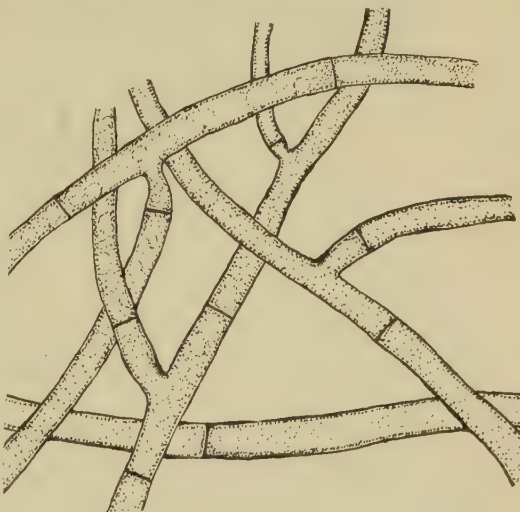


FIG. 33.—Threads of the "damping off" fungus *Rhizoctonia*. (Magnified 625 times.)

2 “*End rot.*”—This term applies to the rot of the lower end of seedlings. It was reported and observed in many places in the State. The beginning of the rot is usually at the lower end. The root shrivels up as it dries, frequently leaving merely a more or less spherical live part attached to the stem (Fig. 34). This finally dies. Wilt of the stalk and leaves usually begins when the root is only partly dead. The roots often show an orange-yellow color on the outside in the beginning stages of the rot. The bud puts out prematurely in such diseased seedlings. The cause is unknown, but it seems to be associated with bad conditions of the soil, especially in regard to moisture.

3 *Millipedes.*—These worms have caused serious loss, especially in seedling beds. They eat the root and any part of the stem in the ground. On lifting wilted stems of seedlings, one often finds them severed. Small roots are frequently cut in two, while larger ones are so badly eaten that wilt often results. These worms are about one-half to three-fourths of an inch long,

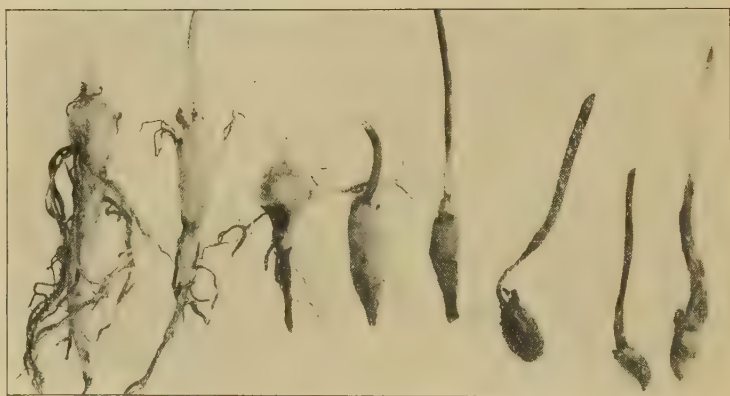


FIG. 34.—*End rot of seedlings.* (Natural size.)

transversely striped with 40–45 grayish and brown rings, and an equal number of pairs of legs. The younger ones are browner. They are hard and shining. Technically they are known as *Julus hortensis*. They are also reported as destructive to potato tubers. They might, therefore, be killed by putting out pieces of potato poisoned with arsenic. They are trapped to a considerable extent by laying down boards under which they gather.

III. NEMATODE ROOT GALL.¹

Distribution of the disease.—This nematode worm occurs chiefly in the latitude of the Gulf States. Its limits, however, are not well known. Dr.

¹ Although this subject strictly comes under the scope of the zoologist, particular attention has been given to it in this country by botanists. This has come about through its connection with plant disease. The subject has been exhaustively treated by Atkinson in Bulletin No. 9, Alabama Agr. Exp. Sta., 1889, and by Stone and Smith in Bulletin 55,

Neal¹ (1889) supposed that it could not withstand the cold of winters north of Savannah. Professor Atkinson (1889) thought from his observations of this worm on deep roots of parsnips and tomatoes, that "if a favorable opportunity should occur for its introduction into our States so far as New York and Ohio, from its habit it might easily pass the winter in sufficient numbers to become a terrible pest." Webber and Orton² in speaking of its distribution, say, "it



FIG. 35.—Root affected with nematodes. (Two-thirds natural size.)

will probably never become a serious malady north of this general region (*i. e.*, the Gulf States), except in greenhouses, as the nematode is killed by severe cold." Bailey³ found that hard freezing of greenhouse soils eliminates the danger from root-galls; and it is now the common practice of gardeners who

Mass. Hatch Sta., 1898. The former from Alabama, deals more with the worm as it occurs out of doors, while the latter has to do with it as occurring in greenhouses. These bulletins are so complete that I would in the beginning, refer any one who is especially interested in nematodes, to them.

¹ U. S. D. A., Div. En. Bull. No. 20.

² Some Diseases of the Cowpea. U. S. D. A. Bur. Plant Industry, Bull. 17, 1902.

³ Cornell Bull. 43, 1892; The Forcing-Book, pp. 85, 177.

have been troubled with the galls to use only soil that has been well frozen. Halsted³ found them on oats in New Jersey. As far north as New England, Sturgis⁴ reports them on asters, out of doors. Stone and Smith⁵ state that they do occur sometimes on outdoor plants, but in such cases, the worm has either been removed from greenhouses or carried in infested manure.

There is no reason why they could not survive the cold of winters in the forest in this latitude. Where soil lies uncovered throughout the winter, as is the case in the cultivation of ordinary farm crops, the worms cannot survive. However, the heavy mulching of beds to protect the roots from cold, together with the snow which usually covers the ground throughout the winter, prevent the destruction of the nematodes by freezing. Aside from the mulching of gardens to protect the roots, it is doubtful whether these worms could withstand the winters of southern Indiana and Ohio any better than of New York



FIG. 36.—Development of the nematode worm, a, g, eggs; j, h, segmentation of egg; b, h, young larvæ; c, l, full grown larvæ; d, e, metamorphosis of male; f, mature male with spear (sp.), m, thickening of female; n, mature female; o, ovary containing eggs (eg.) (a, m, magnified 99 times; n, 40 times.)

where the winters are longer, and on the average, colder. There, the snow is but a poor protector, and the ground freezes to a considerable depth.

³ N. J. Exp. Sta. Rep. 1890, p. 366.

⁴ Conn. Agr. Exp. Sta. Rep. 1892, p. 45.

⁵ Stone and Smith, *l. c.*, p. 176.

Nematodes are known to attack many different species of plants, belonging to widely separated families. For this reason, they are difficult to combat. Plants liable to their attacks should be eradicated in order to starve the worm, or the catch-crop method used. Atkinson gives a list of 36. Kühn states that of the grass and pea families alone, 79 species are susceptible to attack. In the north in greenhouses the rose, violet, cyclamen, tomato, etc., are attacked.

On October 31, 1903, a garden badly affected with nematodes was reported. A visit was made to this place, November 3d. The garden is located at the edge of a wood. In fact, the south end is somewhat shaded by the trees. The slope is east, a little to the north. The soil in the greater part of the garden seemed loose and well aerated.

In making up the beds leaf-mold, wood-ashes, muriate of potash, dried blood, raw bone, two tons to the acre, were added. These were drilled and well worked in. The mulch was mostly of leaf-mold. Some manure was added, making about one and one-half inches in all. The plants were set one inch deep.

Two plats are affected. One which is 32x48 ft. consisting of 5000 plants of various ages, is very badly infested. In this plat in one bed of 602 plants almost every root presented a similar appearance to that shown in Fig. 35. The roots are chiefly four years old from the forest; 85 are four years old from the seed. The plants have been in this plat two years, and about one year ago the presence of galls came to notice. In an adjoining plat there are 6000 plants somewhat affected. Seedlings do not appear to be much affected in these beds. Occasionally galls are formed on them but these are small. They are no doubt badly attacked as soon as the fibers penetrate the soil, but noticeable galls do not often appear before the second year. Cultivated wild roots and those cultivated from seed are alike attacked.

A glance at Fig. 35 will show the external appearance of roots affected with nematodes. They attack the fibers most readily, but may begin at any point on the root. The largest knots seem to be formed on the main roots, although these are fewer in number. A single root may contain hundreds of galls (Fig. 30). These are of any size up to two inches, but their usual size is $\frac{3}{8}$ to $\frac{1}{2}$ inch. One effect of galls is to increase the number of fibers. From a single gall produced on a small fiber, a half dozen or more secondary fibers will be produced. Each of these is frequently as large as the fiber on which the gall was originally produced; sometimes a fiber is even larger below.

The galls are at first more or less smooth and white, but with age become



FIG. 37.—Black rot of ginseng. *Sclerotia* or knots of fungus threads have formed on the surface. (Natural size.)

roughened and show watery translucent spots. This is from the decay within,—the bark not yet being ruptured. The bark soon breaks, however, and if not too badly decayed within, wart or canker-like places are distributed over the surface. These may be mere spots with a rusty-yellow opening or a crack of considerable length and of a like color. Decay usually consumes the entire gall, in the end. Frequently the gall completely collapses on being picked up.



FIG. 38.—*The beginning of soft rot.*
(Natural size.)

forest roots in Seneca County, and at Trumbulls Corner near Enfield, Tompkins County. They might have been carried in infested manure or from some greenhouse.

Treatment.—The killing of nematodes in affected roots would be an impossibility, as any method employed would also kill the root. The removal of the garden to a different location is certainly to be advised, if it be possible; to start with seed or unaffected roots, taking great care not to transfer any of

When there are present on a single root, hundreds of galls and these filled with the worms, there must be some loss of nourishment which should go to the plant. But by far the greatest injury is brought about by the abnormal growth of the galls. The tissue is stimulated to excessive growth at the expense of the remainder of the plant. The part of the root below the gall frequently attains an abnormal size. In these galls the vessels become very irregular and often entirely disconnected. When the gall decays, this portion of the root is also destroyed. Before the roots are placed in the market, the galls and fibers must be stripped, so that the loss is great.

It is the opinion of the owner of this affected garden, that nematodes do not injure the growth of the stalk or lessen the amount of seed. The growth of foliage this year was fine and the badly affected bed of 602 plants, produced 18000 good seed. Such plants might be kept for seed purposes, but in no case should roots be sold except in the dry market.

It is probable that these worms were introduced into the garden from the forest. The owner of this garden has found them on

the worms to the new garden. (The seed if simply taken from the plant will not carry the worms. In case they are picked from the ground they should be dried as much as is safe, to insure not transferring any worms to the stratifying beds.) They could easily be carried by means of tools or perhaps on the shoes of a person walking from an affected garden, especially in wet weather.

Stone and Smith state that a temperature of freezing or of 140° F. is necessary to kill both eggs and worms in the soil, but for practical purposes in sterilizing, the soil should be heated to 180° to 212° . Treating the soil with chemicals was of no practical value. The eggs are well protected and hard to kill. It is a difficult matter to kill all the worms, distributed as they are through the soil. Shovelling up the soil and allowing to dry is an excellent method as the worms perish on drying. Putting the soil in a condition so it



FIG. 39.—A plant injured with unleached ashes and *Alternaria*. The spot a is due to *Alternaria*. (One-fourth natural size.)



FIG. 40.—Spores and spore-bearing stalks of *Alternaria* (About 270 times)

will freeze is a good plan. Perhaps the best method is to steam sterilize the soil. It is worth while to suggest, also, that the mulch be withheld long enough to allow the ground to freeze thoroughly, if it can be done without injury to the plants.

IV. BLACK ROT.

Late in August some roots were sent in by a ginseng grower. A number of black protuberances were on the surface. These were evidently "sclerotia"—that is, more or less rounded or elevated knot-like masses of fungus threads. In Fig. 37 (a) one of these knots shows very distinctly and characteristically. The root shown in Fig. 37 (b) contained a number of these protuberances which are much larger and have in some cases incrustated

the surface for a distance of one-half to one inch. They are black without and within resemble in color the root, but they are firmer.

The roots and rootstocks are of a tar black color, yet if the root should dry somewhat (as it does in the process of photographing) the outer dead cells of the bark would naturally lose the jet black color. The illustration shows this. The roots become black in the bark first and gradually change to the same color in the center. The smaller fibres soon disappear and life becomes extinct. The texture of the root within is gelatinous-spongy and watery. It loses its taste to a great degree, that remaining being somewhat of quinine, and the ginseng taste gradually disappearing. It has no offensive smell or taste characteristic of the soft rot.

This, of course, applies up to the time when the roots have become entirely black. Later, I am informed, the roots become soft and rotten; this must follow, as every part is penetrated by the vegetative part of the fungus.

The grower informs me that these roots were set last fall in a bed from which black roots were taken six or seven years ago and that no ginseng had been in the bed from that time to this. The fungus seems to have attacked the roots during the winter, as they sent up no stems in the spring. He has observed such roots before, and reports that in a small area several hundred became affected during the winter or early spring; for the buds were well formed in the autumn, but failed to grow in the spring.

The above statements point to the fact that this Sclerotium is not only parasitic, but that its mycelium or vegetative threads will

live in the soil for a number of years. In cultures, the mycelium readily produces sclerotia, but so far no fruiting form has appeared.

When such roots are found they should be removed and destroyed if not fit for the dry market; for cultures show that the fungus will propagate by the mycelium which fills every part of the root. Remove from the garden the dirt in affected beds to a depth beyond the deepest roots.

V. SOFT ROT.

Most of the so-called "root-rot" which occurred during the past season was the rot described below. It occurred to some extent in almost every section of the State where ginseng is grown, and is reported from other States. In places the loss from this cause was enormous, and it is certainly

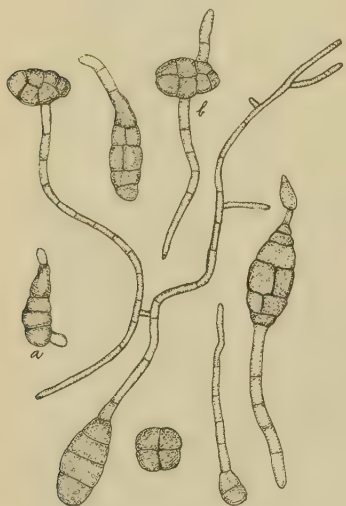


FIG. 41. — *Germinating spores of Alternaria.* (Magnified about 270 times.)

safe to state that the greatest loss of ginseng in 1903 was from this rot. It occurred chiefly from June to August. In July the rotting was at its height. A noted case of this occurred in one of the gardens that I visited, where two-thirds of the plants in one bed died, and about half of those in an adjoining bed. These roots were very large and fine. They were chiefly of wild stock. Some were cultivated five year old roots. They had been set three inches deep.

The beds were inclosed with eight inch boards, four inches in ground. The top of the bed was little, if any, above the level of the walks. That portion of the garden where the rotting was worst was shaded by an apple tree. The garden was poorly ventilated, having two fences within, one on either side of the row of fruit trees. The soil was packed and wet.

This is an extreme case but serves to show the chief causes of soft-rot,—bad conditions surrounding the plant, hastened by the age of the roots. This has occurred for the most part among older plants, and that at the season when they are beginning to develop seed. The putting forth of new stems and obtaining food for the developing seeds is a great effort for the plant. Much of this food is manufactured daily in the leaves, but the root must be drawn upon as a reserve supply. It is less able to survive under unfavorable conditions.

In cases of soft-rot, the root decays very rapidly and is sticky and ill-smelling. The fusarium fungus and bacteria are usually present in great abundance. Whether they are in any way connected with the cause of the disease, I am unable to say. The leaves of plants affected with soft-rot of the root, change to a mixture of red and yellow and soon die. The stem will often separate from the rootstock by the time the rot has only begun (Fig. 38). Frequently the foliage is attacked by Botrytis, another kind of fungus. In this case, the affected areas present a watery appearance and are of a greenish yellow color. I have observed Botrytis on foliage in cases in which the root never decayed. This occurred in midsummer, and is perhaps made possible by the low vitality of the plant. I succeeded in inoculating ginseng leaflets with this fungus when an abundance of moisture was present.

VI. ALTERNARIA or Leaf-spot.

This disease first came to my notice while on a visit to a ginseng garden in central New York, in July, 1903. The leaflets of entire beds were spotted with some disease. The foliage at this time of the year should have been most vigorous and capable of withstanding attacks of fungi other than those of a parasitic nature. Someone employed in the garden in treating the beds had thoughtlessly thrown unleached ashes over the foliage instead of putting it on the ground beneath. It was his opinion at the time that the spotting was due entirely to this, but the spots were so much like those caused by fungi, that I immediately attributed it in part to a parasite. Fig. 39 is from a photograph of a plant thus affected. I also collected excellent speci-

mens of this *Alternaria* in eastern New York. In this case no chemical had been thrown on the foliage.

Although inoculation experiments were not carried on with the fungus, I believe it to be parasitic in its nature. If it be not strictly so, it is an enemy to wounded plants, and would doubtless cause much harm to plants in a weakened condition. Although the spots did not increase greatly in size, or seem to affect the vitality of the plant, they were very numerous and reduced the amount of leaf surface to a considerable extent.

It is of extreme importance to keep the foliage of plants uninjured, not only to prevent certain fungi from gaining a foothold, but to have as large an amount of leaf surface as possible. Never remove any of the foliage, for by so doing one destroys a part of the machine which manufactures the food so essential to the plant for its daily use and for storage in the root and seed.

TECHNICAL ACCOUNT OF THE FUNGUS.

An examination of one of these spots under the microscope showed an abundant growth of a species of a fungus known as *Alternaria*. Even on very minute spots the fungus is present. The spots are circular or nearly so, and frequently attain a diameter of one-half inch in circumference and the edge of the spot is of a reddish-brown color. Inside of this ring, the color is much lighter, and is finally a dingy white as the spot becomes older and increases in size. The leaflet also becomes much thinner in this spot. The hyphae or threads which form the vegetative part of the fungus grow within the tissue of the leaf and take away its vitality. Under a low power of the microscope they may be seen, forming a net-work throughout the entire discolored area. They are brown and divided by cross-walls. In diameter they measure 5 to 7 μ .

From this vegetative part there arises on the surface of the leaf other hyphae or threads which are fertile. These are the spore bearing stalks or conidiophores. They grow both on the upper and under surfaces of the leaflet, and occur in tufts. Fig. 40 shows a tuft of these conidiophores composed of seven stalks. Three of these bear spores or conidia at the top; one (b), shows two spores, one above the other. The conidiophores are somewhat irregular and roughened especially toward the tips. They are brown and usually have about six cross-walls. Their length is ordinarily 100 to 120 μ , although shorter ones sometimes occur. The diameter is 5 to 6 μ .

The spores are brown, muriform (*i. e.*, divided by both cross and longitudinal walls), and borne in chains. Frequently these chains are very long and composed of five or six spores. These soon fall away and leave the stalks standing. The spores are 45 to 65 μ long and 15 to 20 μ broad. These spores may be blown by the wind or carried to other plants, where under favorable conditions, they germinate by sending out one or more tubes as shown in Fig. 41. These tubes penetrate the tissue of the ginseng leaflet, and become very much branched, forming the mycelium as described above. Fig. 41 is from spores germinated in the laboratory.

VII. VARIOUS PESTS.

Aside from the millipede already mentioned, many insect and similar pests have been observed, several of which would afford the entomologist a good field of work.

Snails are perhaps the most important of these animal pests, eating the

foliage and even the stems of young plants. They were a menace to gardens this season.

A good method of extermination is to trap with slices of turnip or lettuce leaves. These may be placed about the garden and turned over from time to time, and the snails killed. With the aid of a lantern at night they may be gathered from the foliage. Carbon bisulfide has been used with good effect, especially by applying along the boards which afford an excellent hiding place for them. Air-slaked lime applied to the soil is said to give good results.

A *scale insect* has been called to my attention. It is attached to the stem and leaf-stalk, and by sucking causes light colored dead spots.

A *stem borer* that tunnels the stem of large plants, causing it to die to the ground, also occurs. This is doubtless the work of the larva of one of the



FIG. 42.—The effect of carbon bisulfide on ginseng plants.

owlet-moths, and related to the cut-worms. Although the root may not be injured, the dying of the stem that bears a hundred or more seeds, is a serious loss.

VIII. GENERAL ADVICE.

Carbon bisulfide as a root insecticide.

Carbon bisulfide has been used to a considerable extent as an insecticide. While good results have been obtained in some cases, in other instances considerable loss has been reported by its use. One ginseng grower, who experimented some with it in ginseng beds after suffering serious loss by its application to the soil, states that when used in quantities of one-half ounce every two feet, destroyed almost all the plants (2 years old) where the soil was a sandy loam, while in clay soil it was not so severe. The chemical was placed four to six inches deep and the soil pressed down over it. The first

injury to the root is visible in the rootlets, which are killed. The fibers and lower part of the root presented a reddish appearance when examined in cross-section. The loss of two to three thousand plants, which was confined entirely to the area where it was used, and the fact that even circular areas of dead plants occurred in many places throughout the beds, point definitely to carbon bisulfide as the cause.

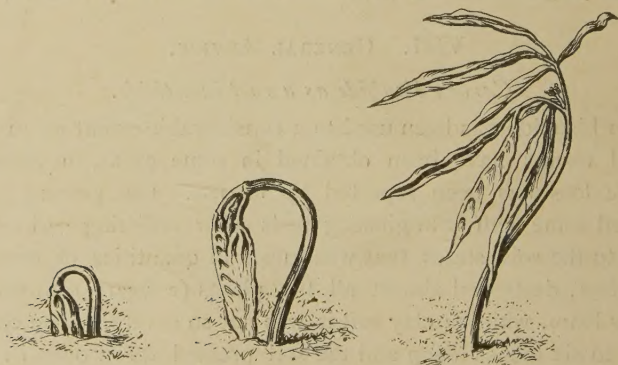
Carbon bisulfide is a good insecticide, but great care must be exercised in its use, especially in preventing the actual contact of the liquid with any part of the root. The character of the soil and amount of moisture must be considered. Fig. 42 shows the disastrous effects, scarcely a plant left standing in the end of this bed.

Handling of Roots.

Too much care can not be exercised in handling ginseng roots. It is true that they will usually grow after rough handling; they will sometimes fail to send up a stem for a season, and apparently retain all their vitality. But that they are killed by lack of care in handling is evident to many growers. I have seen hundreds of roots that have been dug from time to time in the forest, carelessly thrown about, bruised and broken, and finally sold to persons new in the business. The result of planting such roots can be inferred. So in ordinary transplanting, every care should be taken to preserve all the fibers. The plant may not apparently suffer, but each broken fiber is a loss.

From the nature of the principal diseases of the ginseng observed during the past season, a better means of supplying fresh air to the plant under the shades should be provided. The soil should be kept mellow so that it too will be aerated. Many growers already have the entire top of the garden so arranged that it may be opened or closed to any extent in a very short time. This also solves the difficulty from snow during the winter. Fig. 19 shows such an arrangement, and also the double bed with a foot path at the highest point in the middle. The shape of the top conforms to the shape of the beds, and tends to drain the water of beating rains into the main paths.

JAMES M VANHOOK.



Ginseng plants "coming up."